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An Integrative Review of Empirical Research on Perceptions and Behaviors Related to Prescribed Burning and Wildfire in the United States

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Abstract
Social science research from a variety of disciplines has generated a collective understanding of how individuals prepare for, and respond to, the risks associated with prescribed burning and wildfire. We provide a systematic compilation, review, and quantification of dominant trends in this literature by collecting all empirical research conducted within the U.S. that has addressed perceptions and behaviors surrounding various aspects of prescribed burning and wildfire. We reviewed and quantified this literature using four thematic categories covering: (1) the theory and methods that have been used in previous research; (2) the psychosocial aspects of prescribed burning and wildfire that have been studied; (3) the biophysical characteristics of the fires which have been studied; and (4) the types of fire and management approaches that have been examined. Our integrative review builds on previous literature reviews on the subject by offering new insight on the dominant trends, underutilized approaches, and under-studied topics within each thematic category. For example, we found that a select set of theories (e.g., Protection Motivation Theory, Attribution Theory, etc.) and approaches (e.g., mixed-methods) have only been used sparingly in previous research, even though these theories and approaches can produce insightful results that can readily be implemented by fire-management professionals and decision makers. By identifying trends and gaps in the literature across the thematic categories, we were able to answer four questions that address how future research can make the greatest contribution to our understanding of perceptions and behaviors related to prescribed burning and wildfire.

Keywords Risk perceptions · Mitigation behaviors · Collaborative management · Social theory · Mixed-methods · Integrative review

Introduction

Wildfire risk is a complex phenomenon shaped by both natural and anthropogenic forces (Fischer et al. 2016; Roos et al. 2016). Over the past several decades, the number of wildfire ignitions has increased (Calkin et al. 2014) as has the total amount of land burned (Kaval 2009). Additionally, an increasing number of individuals have moved into the Wildland-Urban Interface (WUI), resulting in increased risks to human populations (Shafran 2008). More frequent and intense wildfires and rapid urban expansion, combined with rising land surface temperatures and increasingly variable annual precipitation rates, have resulted in an increase in the risk wildfire poses to humans and the landscapes in which they live.

Rigorous and interdisciplinary social science is needed to understand how individuals prepare for and respond to fire-related risks. A number of reviews have been conducted on specific aspects of the human dimensions of wildland fire, which have synthesized important findings across a number of themes, some of which include: perceived risk, trusted information sources, factors influencing homeowner mitigation, public acceptance of fuels management, community preparedness, and reactions to fire (McCaffrey and Olsen 2012; McCaffrey et al. 2013; Toman et al. 2013). However, previous reviews have not taken an in-depth look at the

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theoretical and methodological frameworks that have guided the majority of previous work on the human dimensions of fire. The purpose of this review is to enhance our current understanding of individual-level perceptions and behaviors in the face of prescribed burning and wildfire by addressing a set of broad research questions through an integrative literature review that involved compiling, reviewing, and quantifying the dominant trends and gaps in previous literature. Specifically, our integrative review adds to the existing literature and expands on previous literature reviews by examining the theories and methodological tools that have been used to generate our understanding of perceptions and behaviors related to prescribed burning and wildfire. This specific focus on theory and methods has not been the focus of previous reviews, and complements our current knowledge on the relationship between humans and fire (McCaffrey and Olsen 2012; McCaffrey et al. 2013; Toman et al. 2013).

Integrative reviews use a rigorous search and review process to identify gaps and trends in previous work done on a specific research topic. Through our integrative review, we coded and quantified important aspects present across all previous empirically grounded research related to individuals' perceptions and behavioral responses to prescribed burning and wildfire. Our coding process was structured around four thematic categories: (1) theory and methods used; (2) psychosocial aspects of fire; (3) biophysical aspects of fire; and (4) fire type and management. Our intent with the integrative review is to uncover trends and gaps in our collective body of knowledge in order to guide future research related to the human dimensions of prescribed burning and wildfire. Specifically, the review addresses four general research questions:

1. What theories and methodologies have been used to understand individual perceptions and behaviors related to prescribed burning and wildfire?
2. What groups of individuals have been studied in the past, and how can we include under-studied groups to improve our understanding of these groups' perceptions and behaviors related to prescribed burning and wildfire?
3. What biophysical aspects of prescribed burning and wildfire have been less focused on in previous research and can they be the focus of future research to enhance our understanding of prescribed burning and wildfire as a socio-ecological phenomenon?
4. How has climate change and multiple forest disturbances/hazards been included in previous work?

Materials and Methods

Integrative Reviews

Integrative reviews compile, review, critique, and synthesize a body of research to conceptualize novel perspectives

(Torraco 2005) and recognize trends and gaps on a narrow, focused topic. Integrative reviews are appropriate for emerging as well as mature bodies of literature as they offer an all-encompassing view of a topic, highlighting where future research is needed or where conflicts exist among published work (Torraco 2005). This integrative review concentrates explicitly on the psychological and behavioral social science literature addressing individuals' perceptions and behaviors in the face of prescribed burning and wildfire risk.

Criteria Statements

To be included in the review, a paper must have reported on a study which:

1. occurred within the United States;
2. was directly related to some aspect of prescribed burning or wildfire;
3. included one or more of the following keywords:

   a. risk,
   b. attitudes,
   c. perceptions,
   d. decision making, or
   e. mitigation;

4. focused on forestland (i.e., studies focused exclusively on rangelands, grasslands, or other non-forested land uses were excluded); and
5. used empirical (primary) data.

Empirical (primary) data includes methodologies which collected qualitative or quantitative data on human populations.

Article Selection

We conducted an initial literature search on May 12, 2016 to identify all research relevant to the criteria statements. The search was conducted through four databases/repositories: EBSCOHost; Web of Science; the Utah State University Library; and Google Scholar. Each database/repository was searched using the following keyword strings:

1. perceptions of wildfire;
2. perceptions of prescribed burning;
3. perceptions of wildfire and prescribed burning;
4. perceived risk of wildfire;
5. perceived risk of prescribed burning; and
6. wildfire mitigation.

The initial literature search produced 187 potentially relevant articles. Three additional searches were conducted

(May 11, 2017; September 20, 2017; and February 27, 2018). The two searches in May and September produced 14 more recent publications, whereas the search in February did not yield any new publications. We individually reviewed each of the articles to determine if each met the criteria statements. A total of 74 articles met all of the criteria statements. Articles that were excluded from the review either did not meet all of the criteria statements, were based on replication of data/results in another article, or had a non-empirical basis. Following McCaffrey et al. (2013), we excluded studies with a focus on economic aspects of prescribed burning or wildfire due to their use of specific methodologies (e.g., willingness to pay methods, stated choice methods, etc.).

Coding

We developed a deductive coding scheme based upon our experience and knowledge related to the human dimensions of natural resource management. These codes were organized within four thematic categories:

1. theory and methods used;
2. psychosocial aspects of fire;
3. biophysical aspects of fire; and
4. fire type and management.

Codes were iteratively revised as the papers were read and coded. Additional codes were added based on the emergence of common themes. This process created a total of 16 codes, which included questions and sub-questions, in addition to bibliographic codes that organized the database. The thematic categories, codes, and questions are detailed in Table 1. The full list of previous studies meeting the criteria statements, along with their codes and sub-codes, are provided in the Supplementary Material. Each thematic category addresses one of our guiding research questions.

Thematic Categories

Theory and methods used

The theory and methods used thematic category sought to answer the question: 'what theories and methodologies have been used to understand individual perceptions and behaviors related to prescribed burning and wildfire?' and was comprised of five codes. The unit of analysis code was included to assess the extent to which previous research has focused on individuals, as opposed to aggregated sets of individuals (e.g., communities, cities, or other geographic regions). Relative to studies of individuals, we expected analyses focused on communities would be more likely to address topics such as normative beliefs, peer influence, and social acceptability (Bihari and Ryan 2012; Bright and

Newman 2006; Gordon et al. 2010, 2012). The sampling requirements code was created to get an idea of the basic sociodemographic characteristics of stakeholders studied throughout the literature. The data collection method code was included to assess the basic data collection methods used across the literature. Previous research suggests different stakeholder groups have preferred modes of communicating with scientists and outreach specialists. This code may help shed light on which methods are most effective at reaching specific groups. The social science theory code was included to identify the theoretical frameworks used in the literature, and shed light on the common, as well as underutilized methods of understanding individuals' perceptions and behaviors in the face of prescribed burning and wildfire risk. We also recorded other social science theories used to ensure other theories or concepts present in the research were not overlooked.

Collectively, the questions asked through this thematic category can: (1) identify the types of stakeholder groups that have been studied most and least often; (2) highlight the methods of data collection that are commonly employed to understand the perceptions and behaviors related to prescribed burning and wildfire; and (3) determine which social science theories have been used to frame our understanding of perceptions and behaviors related to prescribed burning and wildfire. Understanding how previous research was framed can offer insight into the methodological gaps present within the literature. By identifying these gaps, future research will be more prepared to address them and ultimately generate a more holistic understanding of how people perceive and respond to prescribed burning and wildfire. These gaps highlight less commonly used methodologies that can offer novel approaches in social science research, which can lay the groundwork to uncover results that were previously dormant.

Psychosocial aspects of fire

The psychosocial aspects of fire thematic category answered the question: 'what groups of individuals have been studied in the past, and how can we include under-studied groups to improve our understanding of these groups' perceptions and behaviors related to prescribed burning and wildfire?' through three codes. The type of stakeholder code was included because individuals with different levels and types of involvement with fire may have different cognitive and behavioral patterns that influence their decision-making related to prescribed burning and wildland fire. Thus, it is important to see which groups of individuals have been studied and in what way (Asah 2014; Bowker et al. 2008). The fire aspects studied code was a focal point in the coding process, since it identified the specific perceptions and/or behaviors previous work has focused on. By quantifying

Table 1 Coding scheme for previous empirical research on perceptions and behaviors related to prescribed burning and wildfire

Code	Question	Code(s) for Review	Subquestion
Theory and methods used			
Unit of analysis	What is the unit of analysis at which perceptions are being measured/compared?	• Individual • Community • City • Other geographic region • Multiple units of analysis	N/A
Sampling requirements	Were there specific sampling requirements?	• Yes • No	If the answer to the above question is 'yes', describe the sampling requirements (ownership characteristics such as: 10+ ac. of forest, forestland owned in contiguous property next to NF, etc.,…)
Data collection method	What was the data collection method?	• Mail survey • Internet-based survey • Focus groups • Interviews • Secondary data • Policy documents • Other	If the answer to the above question is "other", please describe what the method of data collection was.
Social science theory	Does the paper use one or more social science theories?	• Yes • No	If the answer to the question above is 'yes', describe which social science theory was used and note whether it was explicitly tested (e.g., 'Theory of Planned Behavior; Discussed, but not tested'). If the answer to the above question is 'no', enter 'n/a'.
Psychosocial aspects of fire			
Type of stakeholder	What is the unit of observation from which data were collected? A sample of…	• General public • Private landowners • Homeowners (including residents) • Recreationists • Multiple • Forestry/fire professionals • Other	If the answer to the above question is 'other', please describe what the unit of observation is:
Fire aspects studied	Which aspects of fire are studied (not just discussed)?	• Attitudes • General perceptions • Risk perceptions • Decision making • Mitigation strategies/implementation • Other perceptions (affect, place attachment, etc.,…) • Support for management	N/A
Perceptions of containment/management	Perception of containment/management options present (Yes v. No)	• Yes • No	N/A
Biophysical aspects of fire			
Geographic location	What is the geographic location of the study?	• Pacific Northwest • Intermountain West • Southwest • Southeast and Southcentral	Describe any important details of the geographic location (multiple counties, recent wildfire, etc…)

Table 1 (continued)

Code	Question	Code(s) for Review	Subquestion
		• Atlantic Coast	
		• Northeast	
		• Midwest and Upper Midwest	
		• Great Plains	
		• Other	
Forest ecosystem type	Which type of forest ecosystem does the paper address?	• Natural hardwood	N/A
		• Natural pine	
		• Planted hardwood	
		• Planted pine	
		• Mixed hardwood and pine	
		• Other	
Human population type	Does the paper focus on human population in rural or urban areas specifically?	• Urban populations only	N/A
		• Rural populations only	
		• Both urban and rural	
		• Wildland–Urban Interface	
Fire type and management			
Fire policy	Does the paper address specific policies that can/are being used to mitigate or adapt to fire risk?	• Yes	If the answer to the above question is 'yes', which specific policies? Enter 'n/a' if the answer to the above question was 'no'.
		• No	
Climate change	Does the paper address climate change specifically?	• Yes	If the answer to the above question is 'yes', describe how climate change is addressed (e.g., as a factor causing increased fire risk). Enter 'n/a' if the answer to the above question is 'no'.
		• No	
Fire type	What types of fire does the paper address?	• Rx burning	N/A
		• Wildfire	
		• Rx burning and wildfire	
Forest management	Are there other related forest management (mitigation) activities discussed?	• Mechanical thinning	N/A
		• Chemical thinning	
		• Both mechanical and chemical thinning	
		• Other	
Number of disturbances	Does the paper measure perceptions of multiple forest disturbances (e.g., fire + invasives), or just fire?	Number of disturbances	• Single (just fire)
			• Multiple (fire + invasives)
			• Multiple (fire + flooding)
			• Multiple (fire + natural hazard)
			• Multiple (fire + one other)
			• Multiple (fire + multiple others)

which perceptions and behaviors have been studied, in what way, and to what extent we can help shed light on specific types of perceptions and behaviors that are worthy of attention. The final code, perception of containment/management, was included to provide insight into whether or not participants' perceptions of fire containment or management have been addressed. This code was important in determining whether previous research has assessed fire management broadly or as a more complex process. The questions in this category can: (1) create a broad picture of the extent to which individual stakeholder groups have been analyzed to identify specific groups that should be prioritized in future research; (2) identify trends in the dominant psychosocial aspects of wildfire that have been analyzed, and which should be prioritized in future research; and (3) determine whether or not fire management, as opposed to fire risk, should be analyzed in future research.

Biophysical aspects of fire

The biophysical aspects of fire thematic category sought to answer the question: 'what biophysical aspects of

prescribed burning and wildfire have been less focused on in previous research and can they be the focus of future research to enhance our understanding of prescribed burning and wildfire as a socio-ecological phenomenon?' and was comprised of three codes. The geographic location code was used to identify the region where the study took place, which included more specific information when applicable. Combined with spatially-explicit data of fire risk, this information could be used to identify how frequently specific areas have been studied relative to their actual fire risk (Bright and Newman 2006). The forest ecosystem type code allowed us to hone down analysis from a regional perspective to specific forest ecosystem types. Forest ecosystems across the United States have different wildfire regimes and variable levels of overall fire risk; it is crucial to analyze human dimensions in light of this fact. For example, home or landowners in different forest ecosystems will likely have varying forest management objectives and decision-making strategies, making it critical to analyze these individuals at the scale of the forest ecosystem in which they reside. The final code, human population type, was included to distinguish between urban and rural populations as well as those residing within the WUI. This code was included given individuals living at different population densities will be exposed to different levels of fire risk and potential economic and environmental impacts.

Collectively, the questions in this thematic category can: (1) identify the geographic regions where perceptions of fire risk research has been concentrated; and (2) determine if these concentrations align with projections of where fire risk is expected to be the greatest in the future.

Fire type and management

The fire type and management thematic category answered: 'how has climate change and multiple forest disturbances/hazards been included in previous work?' through five codes. The fire policy code highlights what fire policies study participants have been asked about. The climate change code was included given the recent push towards understanding individuals' perceptions of and beliefs about climate change. This is important because it is evident that wildfire occurrence will continue to rise in the future as temperatures rise and precipitation becomes more variable, especially in the western United States (Westerling et al. 2006). The fire type code was included to gain a better understanding of the level of synergistic fire perception assessments (i.e., are most studies assessing individual fire types or a combination?). Since forest management activities can impact level of wildfire risk, the forest management code was included to assess the extent to which study participants have been asked about their awareness of, and/or implementation of, such activities. To quantify how many forest

disturbances were addressed in each study, the code number of disturbances was used. Responses to this code were combined into three response options for analysis: single (just fire); fire plus one other; and fire plus two others.

Collectively, the questions in this thematic category can: (1) quantify the extent to which previous literature has assessed climate change and forest policy relative to wildfire; (2) determine the extent to which studied populations have been asked about their awareness of, and/or preferences for, fire-management activities; and (3) allow us to understand how commonly fire is studied in conjunction with other forest threats such as invasive species and flooding.

Results

To address our guiding research questions within each thematic category, we provide an overview of findings from reviewed articles, along with a brief discussion of how these findings can be utilized in addressing future research questions that will contribute to our collective understanding of how people perceive, plan for, and respond to fire. Our analysis was guided by four thematic categories and concomitant research questions, which produced a number of key findings (Table 2).

Theory and Methods Used

The studies reviewed predominantly analyzed perceptions and behaviors related to prescribed burning and wildfire at the level of the individual (Fig. 1). Around 83% of analyses were conducted at the individual level, and a smaller number of studies aggregated individual-level data to a community-level for the purpose of comparing multiple communities (Bihari and Ryan 2012; Gordon et al. 2010, 2013, 2012; Paveglio et al. 2009) (8%). Another small group of studies analyzed perceptions and behaviors across multiple units of analysis (e.g., a study across multiple communities in the U.S. and Canada) (combined 6%).

As shown in Fig. 2, just over half of the literature utilized a form of survey for data collection (53%). Of this percentage, 43% utilized mail surveys, 7% used phone surveys, 3% used a drop-off pick-up survey, and one study used an Internet-based survey. Just under 12% of the studies reviewed used interviews as the main methodology and 19% utilized a mixed methodology. The studies employing mixed methods used: a focus group and internet/mail surveys; a longitudinal survey; a mail survey and field interviews; a workshop and an experiment; a survey and follow-up questionnaire; a phone-mail-phone method; and secondary (National Wildfire Program) data combined with a manager survey. The 'other' category took up the remaining

Table 2 Research questions and key findings for each thematic category of analysis in this integrative review

Thematic category	Research questions	Key findings
Theory and methods used	What theories and methodologies have been used to understand individual perceptions and behaviors related to prescribed burning and wildfire?	• More novel, mixed-method approaches are needed • A more diverse set of theories, beyond the theory of planned behavior, need to be used
Psychosocial aspects of fire	What groups of individuals have been studied in the past, and how can we include under-studied groups to improve our understanding of these groups' perceptions and behaviors related to prescribed burning and wildfire?	• A more in-depth understanding of fire professionals' perceptions and behaviors is needed • More definitive work on the factors associated with intent to mitigate wildfire risk is needed
Biophysical aspects of fire	What biophysical aspects of prescribed burning and wildfire have been less focused on in previous research and can they be the focus of future research to enhance our understanding of prescribed burning and wildfire as a socio-ecological phenomenon?	• Future work is needed on perceptions and behaviors as a function of forest ecosystem type • Continued focus on the WUI can open up the possibilities for longitudinal analyses
Fire type and management	How has climate change and multiple forest disturbances/hazards been included in previous work?	• Climate change needs to be more thoroughly integrated into future work • More work is needed on perceptions and behaviors related to multiple forest disturbances
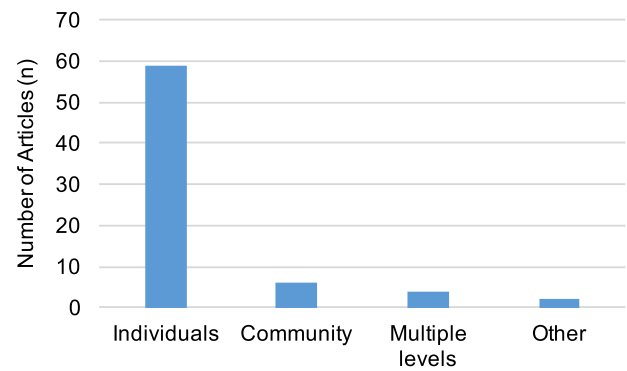
Fig. 1 The unit of analysis in previous empirical work on the perceptions and behaviors of prescribed burning and wildfire
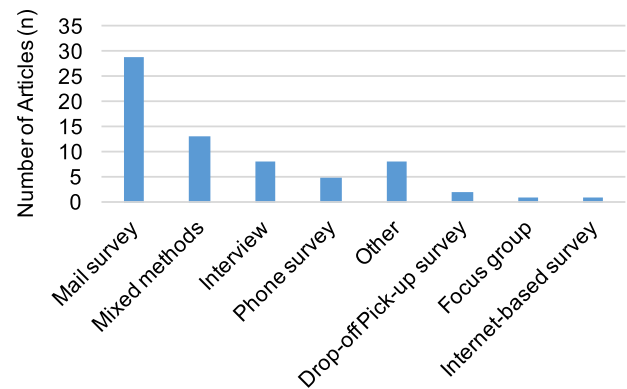
Fig. 2 Methodology used for data collection in previous empirical research on the perceptions and behaviors of prescribed burning and wildfire

12% of the studies with some examples of 'other' methodologies including: Q-methodology; two-phase quasi-experimental designs; hazard assessments; secondary data; virtual reality technology; and program evaluation.

Nearly 40% of the studies reviewed were framed by a social science theory (i.e., theory was mentioned in the introduction and/or literature review) to guide the empirical analyses. The most widely used theories included the Theory Of Planned Behavior (5%) and Protection Motivation Theory (5%). Although not a theory per se, the Grounded Theory process was also used multiple times (7%). Other theories used to guide empirical analyses (each used only once) included: Attribution Theory; Causal Attribution Theory; Community Field Theory; Norm Theory; Social Capital Theory; the Theory of Reasoned Action (an extension of the Theory of Planned Behavior); and various psychological models of risk. In addition to those noted above, several other theories have been utilized by only one or two studies.

Our review also allowed us to identify additional constructs discussed and/or used to guide empirical analysis of fire-related perceptions and behaviors. Constructs are latent

variables that are not easily measured; they include things like personality traits, intelligence, attitudes, and emotional states. The psychological constructs which have been used in previous research on fire-related perceptions and behaviors included attitudes, general risk perceptions, perceived behavioral control (measured in isolation and not as part of the Theory of Planned Behavior), place attachment, social vulnerability, special places, subjective norms (again in isolation and not as a part of the Theory of Planned Behavior), and trust.

Psychosocial Aspects of Fire

Half of the studies reviewed collected data on homeowners/residents (Fig. 3). Approximately 12% collected data on landowners, another 9% was data collected from the general public and 10% were from 'other' stakeholders. Some examples of 'other' stakeholders included: those identified as important/influential by USFS employees; undergraduate students; media representatives; firefighters/ambulance drivers; local elected officials; state and federal government employees in natural resources; religious leaders; environmental organizations; and business groups. Only 6% analyzed forestry and fire professionals and 3% collected data from recreationists. This is notable, given the importance of forestry and fire professionals in all aspects of wildfire (Sexton 2006), and the potential losses that recreationists may face from wildfire destruction (Bawa 2016).

The studies reviewed had a total of seven common aspects of fire that were studied and not just discussed in the introduction or literature review sections. These seven aspects included: attitudes; general perceptions; risk perceptions; decision making; mitigation strategies and/or implementation; support for management; and other perceptions. The frequency of all response categories was relatively consistent (Fig. 4). Risk perceptions were the
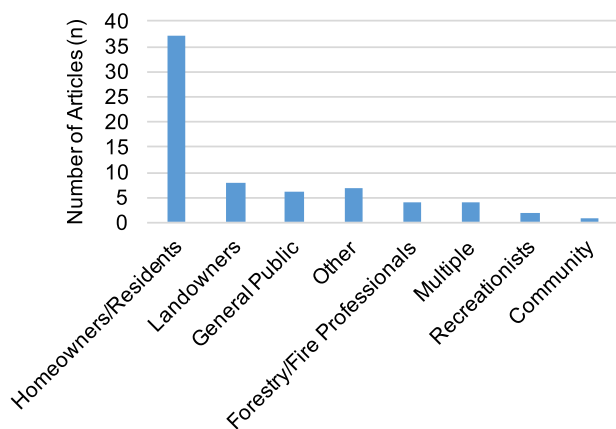
most frequently cited, appearing in 50% of the studies, with support for management analyzed in 46%, attitudes in 45%, general perceptions in 42%, other cognitions mitigation strategies/implementation in 41%, and mitigation strategies/implementation in 36%. Decision making was the least commonly studied aspect, appearing in only 14% of the studies reviewed, and just under half of the studies (42%) assessed the perception of containment or management.

Biophysical Aspects of Fire

We included the geographic location code to understand the geographic distribution of the previous research. The majority of study sites were in the Intermountain West (39%) or the Pacific Northwest (27%) (Fig. 5). A handful of studies were conducted in the Midwest and Upper Midwest (11%) along with the Southeast and Southcentral areas of the United States (12%). Only a small number of studies have been conducted in the Southwest (9%), with three in the Northeast, and one in the Atlantic coast. No studies have been conducted in the Great Plains, and a small number were categorized as 'other' (7%). Examples of a study categorized as 'other' include: a national study of six fire-prone communities across the U.S. (Bihari and Ryan 2012); a study using data collected from the National Survey on Recreation and the Environment (Bowker et al. 2008); and a virtual reality scenario from the Ashley National Forest in Utah (Fiore et al. 2009).

Most of the studies reviewed did not explicitly identify the type of forest ecosystem assessed (84%). Of the 12 studies (16%) that did, the most common forest ecosystems were mixed hardwood and pine, natural pine, or natural hardwood. Not surprisingly, just under half (43%) of the reviewed research has been conducted in WUI areas (Fig. 6). The second most common area was a mix of both urban and rural areas (18%). Less common were studies focused explicitly on rural areas (9%). Only a handful of studies were conducted in rural and WUI areas (5%), along with some combination of: rural; suburban; urban; and WUI (combined 4%). The remaining 11 studies were classified as 'N/A' when managers were surveyed or virtual reality technology was used.

Fire Type and Management

The majority of studies did not address policies used in wildfire mitigation or adaptation, other than mentioning it briefly in the introduction. Nearly 84% of the studies do not address wildfire policy at all, and only 16% addressed specific mitigation/adaptation policies. Of those, about 9% cited the National Fire Plan, just under 8% cited the Healthy Forests Restoration Act, and a couple mentioned the Healthy Forests Initiative. Other programs or information

Fig. 3 Stakeholder groups assessed in previous empirical research on the perceptions and behaviors of prescribed burning and wildfire

Fig. 4 Psychosocial aspects of fire measured in previous empirical research on the perceptions and behavioral aspects of prescribed burning and wildfire
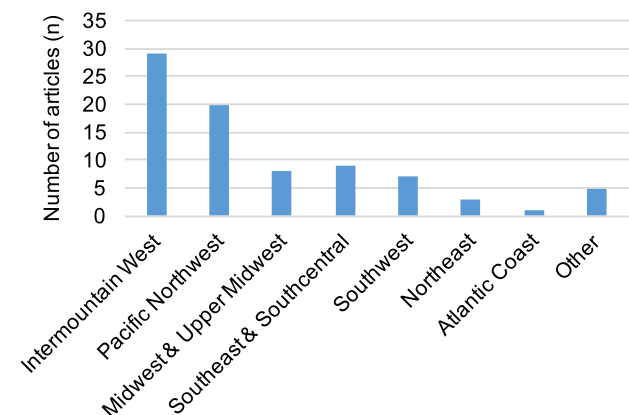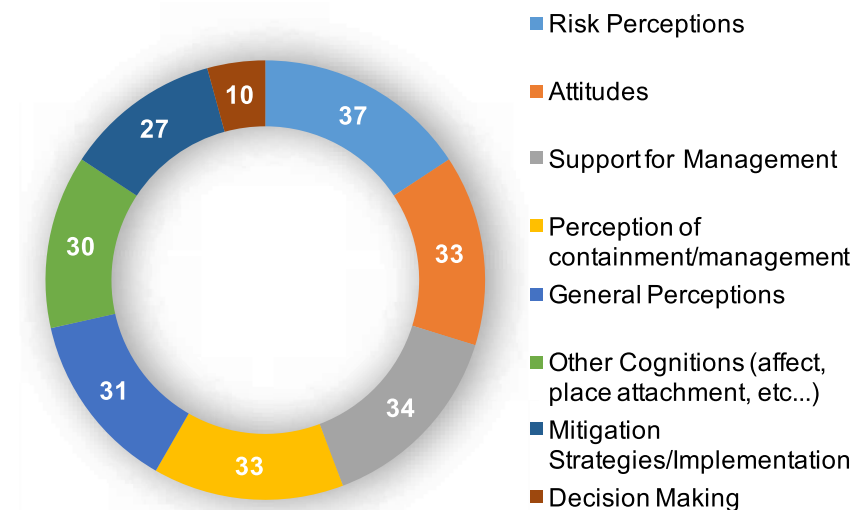

- Risk Perceptions
- Attitudes
- Support for Management
- Perception of containment/management
- General Perceptions
- Other Cognitions (affect, place attachment, etc...)
- Mitigation Strategies/Implementation
- Decision Making

Fig. 5 Geographic locations in previous empirical research on the perceptions and behaviors of prescribed burning and wildfire
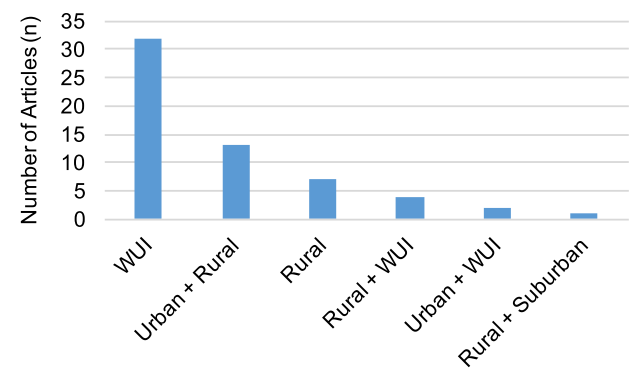

Fig. 6 The rural-urban focus (from the USDA urban-rural continuum codes) of previous empirical research on the perceptions and behaviors of prescribed burning and wildfire

sources were sparsely mentioned (Community Wide Protection Plans, FireWise Communities, and Fire Learning Networks).

The vast majority of studies do not specifically address climate change (97%), with only two studies specifically addressing homeowner perceptions of the influence of climate change and climate variability on wildfire risk (Ojerio et al. 2011; Schulte and Miller 2010).

To understand what types of fire were addressed in the literature, the fire type code was developed to distinguish between: wildfire; prescribed burning; both wildfire and prescribed burning; and other types of fire (Fig. 7). Just over half of the studies address only wildfire, whereas only 7% addressed only prescribed burning. Nearly 33% of the studies assessed both wildfire and prescribed burning, and only one study assessed 'other' types of fire, which simply described and assessed general forest fires with no specification of fire type.

Along the same lines, the forest management code was included to determine if previous work addressed individuals' perceptions of other mitigation-related forest management activities, such as mechanical or chemical thinning. Since forest management is a mitigation tool, it was important to understand whether or not stakeholders' perceptions of these tools have been assessed. These types of data can provide insight into the levels of stakeholder awareness regarding mitigation strategies, which is crucial to developing a holistic understanding of the perceptions surrounding prescribed burning and wildfire. Only 34% discuss some other mitigation-related forest management activity, of those just over 22% discussed mechanical thinning while 8% discussed mechanical thinning and other activities such as chemical thinning, herbicide treatments, or brush removal. A small set of papers (4%) discussed 'other' mitigation strategies; these included: grazing; creation of defensible space; shrub removal; and general fuel reduction.
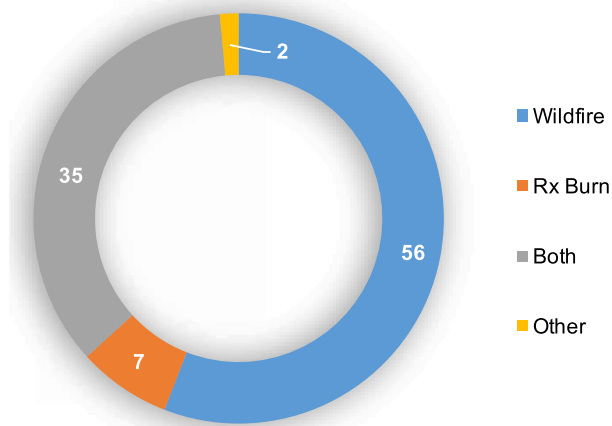
Fig. 7 Individual and combined fire types assessed in previous empirical research on the perceptions and behaviors of prescribed burning and wildfire

The number of disturbances code was used to determine if previous empirical research has addressed perceptions and behaviors concerning cumulative forest disturbances (e.g., fire and natural hazards) or just prescribed burns/wildfire. The vast majority (91%) of the studies had only addressed fire, whereas 7% addressed fire and an additional disturbance. Only one study addressed fire and two additional disturbances.

Discussion

The frequency and intensity of wildfires are predicted to increase in coming years, especially in areas that will become more arid (Flannigan et al. 2009). Continued research efforts across the social sciences are needed to ensure mitigation and adaptation policies and practices are well designed, implemented efficiently, and lead to desirable outcomes. This review has identified trends and gaps in previous research on perceptions and behaviors related to prescribed burning and wildfire. Through this process, we have been able to identify areas where future research can contribute to our collective understanding of how people perceive, plan for, and respond to fire. Our analysis was guided by four thematic categories, each of which is associated with a general research question. Below, we discuss notable patterns observed across the literature and targeted research needs within each of the thematic categories. Our intent is to provide guidance for future social science research focused on prescribed burning and wildfire so that it can have meaningful impacts on fire policy and management in the United States.

What Theories And Methodologies Have Been Used To Understand Individual Perceptions And Behaviors Related To Prescribed Burning And Wildfire? (Theory and Methods Used)

More novel, mixed-method approaches are needed

Over half of the research reviewed utilized some form of (mail, internet, phone, and drop-off/pick-up) survey methodology, and only 19% used mixed methods. This is especially noteworthy considering the recent push for the inclusion of multiple methodologies to improve reliability and validity (Johnson and Onwuegbuzie 2004). Triangulation can be used to cross validate the findings derived from two or more methods, ensuring results are not a methodological artifact. One exploratory study in this integrative review used mixed methods via mail surveys and in-person interviews to triangulate results on how those with wildfire experience (e.g., evacuation, etc.) attribute the cause of fire-related damage, compared to those with no experience (Kumagai et al. 2004). Results from this study show that individuals with recent fire experience attributed the cause of damage to fire officials and nature, and not their own actions or inactions. Underutilized mixed methods, such as pre- and post-fire surveys, that test less common theories (e.g., Attribution Theory) enhance our understanding of how experience with fire and temporality influence the way homeowners attribute blame, and have valuable management implications for outreach and education targeted at homeowners (Kumagai et al. 2004).

We suggest using multiple methods to answer complex questions dealing with people and fire because it has greater potential to reveal more than any single methodology alone. Future work should continue to combine quantitative methods (e.g., drought monitors, previous wildfire locations, high risk forest stands, etc.), with qualitative methods (e.g., interviews, focus groups) and/or secondary data to triangulate results from multiple methodologies; this may lead to novel conclusions about stakeholder-specific risk perceptions, decision-making processes, and other perceptions relate to actual wildfire risk and prescribed fire exposure.

A more diverse set of theories, beyond the Theory of Planned Behavior, need to be used

Nearly 40% of the studies in this review explicitly used social science theory. The most commonly used theories were: the Theory of Planned Behavior and Protection Motivation Theory. The Theory of Planned Behavior suggests behavior is deliberative, and can be predicted based on individuals' attitude toward the behavior, subjective norms,

and perceived behavioral control (all of which are driven by different beliefs). These factors influence individuals' behavioral intentions and actual behaviors. Because the Theory of Planned Behavior has been used widely in perception, attitude, and behavior studies across the social sciences, many researchers have begun to branch out and explore the influence of additional psychosocial factors (outside of attitudes towards the behavior, subjective norms, and perceived behavioral control) on behavioral intentions (Bates et al. 2009; Brenkert-Smith et al. 2012; Hall and Slothower 2009; Vogt et al. 2005). For example, Bates and his colleagues (2009) evaluated the association between knowledge of wildfire causes and mitigation intentions, while also evaluating the common psychosocial factors included in the Theory of Planned Behavior. The research found knowledge of wildfire impacted perceived behavioral control, which in turn impacted the behavioral intention to mitigate fire-related risks (Bates et al. 2009). Another recent study (Brenkert-Smith et al. 2012) explored how the common psychosocial factors included in the Theory of Planned Behavior, as well as additional covariates (demographic and parcel characteristics, risk perceptions, experience with wildfire, social interactions, and information sources used) influenced the mitigation behaviors of residents living within high fire risk areas of the WUI. Brenkert-Smith and her colleagues found receiving information from fire professionals had a strong, positive relationship with residents' mitigation behavior. Two additional factors, belief that the vegetation on their property contributed to risk and experience with wildfire (evacuation), also increased the likelihood of engaging in mitigation behavior. These two studies highlight how emerging research is beginning to explore a wider collection of explanatory variables than the requisite ones associated with the Theory of Planned Behavior.

Other authors have begun to integrate hazard theories to capitalize on the benefits of including multiple theories into a framework or model; this can help tease apart predictor and mediator variables that have been found to be significant in research using a single theory (McFarlane et al. 2011). For instance, Hall and Slothower (2009) utilized the Theory of Planned Behavior along with Protection Motivation Theory to survey Oregon coastal residents on how experience impacts willingness to implement defensible space on their property as well as participate in a risk-reduction program. In this study, experience with wildfire was an important predictor of an individuals' intention to mitigate wildfire risk, and interest in risk-reduction programs (Hall and Slothower 2009). An interest in risk-reduction programs is a good indicator that individuals are concerned about mitigating risk on their property, and are more willing to seek out and receive information from fire professionals. Integrating additional covariates, or theories like Protection Motivation Theory, into future research

designs or theoretical models will continue to clarify the relationship between homeowner perceptions, and how these translate into mitigation/protective behaviors. However, it is equally as important to utilize newer theories and methodologies outside of those commonly explored with the Theory of Planned Behavior.

Heuristics, such as affect, are useful when addressing issues related to humans and fire. A recent study (Ascher et al. 2013) assessed how affective response, exposure, individual knowledge, and perceived risk influenced public support for fuels management (prescribed burning and mechanical thinning). The authors found support for prescribed burning and mechanical thinning was driven by affective response and perceived benefits of the fuels treatments. Affect significantly influenced the perceived risk associated with prescribed burning, which in turn significantly influenced individuals' level of support towards burning (Ascher et al. 2013). Heuristics and other branches of decision theory are worth delving into, since individuals often make snap judgments based on perceptions, attitudes, prior experience, and other behavioral determinants that can have long term consequences which are not apparent while making the decision.

What Groups Of Individuals Have Been Studied In The Past, And How Can We Include Under-studied Groups To Improve Our Understanding Of These Groups' Perceptions And Behaviors Related To Prescribed Burning And Wildfire? (Psychosocial Aspects of Fire)

A more in-depth understanding of fire professionals' perceptions and behaviors is needed

Fire professionals have been largely overlooked in previous social science work on prescribed burning and wildfire; our review revealed only 6% of previous empirical work has focused on fire professionals. Logistically, this makes sense when considering the methods used in previous studies (i.e., interviewing fire professionals during the fire season may not be as feasible as interviewing homeowners during the fire season). However, since these individuals are at the front line of fire management, understanding their perceptions and decision-making strategies could provide a number of benefits to policy-makers, as well as the social science community focused on prescribed burning and wildfire.

A recent study assessed the differences in risk perceptions between WUI residents and wildfire professionals (Meldrum et al. 2015), finding gaps in risk perceptions between the two groups. When asked about specific property attributes (e.g., combustibility of the roof, siding, and deck, and distance from house to combustible material)

associated with wildfire risk, residents and wildfire professionals had different assessments with residents underweighting risk compared to professionals. Another study examined if biases and heuristics affect the behaviors of U. S. Forest Service incident command and line officers (Wilson et al. 2011). Wilson and her colleagues found fire managers are relatively risk neutral, and had neutral opinions about fire use and suppression; use is more beneficial than suppression, but neither were viewed as exceptionally safe or risky. Managers chose the safe option when the consequences were positive (potential gains), and individuals who were labeled 'risk seeking' were less likely to follow this trend. Managers with more experience were found to demonstrate a status quo bias when prescribed fire was the status quo (Wilson et al. 2011). The studies by Wilson et al. (2011) and Meldrum et al. (2015) have shed light onto the value of identifying the key factors shaping the decisions of those individuals who are on the front lines of managing prescribed burns and wildfires. Fire professionals have unique opinions on public perceptions of and attitudes towards wildfire; their decision-making strategies also directly affect the risks associated with prescribed burning as well as wildfire mitigation and response. Consequently, they should be the focus of more empirical social science research in the future (Asah 2014).

More definitive work on the factors associated with intent to mitigate wildfire risk is needed

The literature reviewed here showed individuals' risk perceptions and their decisions to implement mitigation activities on their property is inconclusive, as a wide variety of factors have been found to influence homeowners/residents' willingness to take action to reduce their fire risk. For example, recent research has found homeowner willingness to create defensible space was contingent upon attitudes towards and perceived efficacy of defensible space (Hall and Slothower 2009). Another recent study revealed common sense/risk awareness, aesthetics, and agency outreach as main reasons to implement defensible space (Toman et al. 2011). In another study, preparing for or being involved in an evacuation, as well as high risk perceptions, were identified as factors influencing homeowners' willingness to engage in mitigation activities on their property (Brenkert-Smith et al. 2012). However, results from another study show risk perception as a necessary, but insufficient, condition for homeowners/residents to take mitigation actions (McCaffrey et al. 2011). Another study (Martin et al. 2009) found homeowners risk perceptions were mediated by knowledge and locus of responsibility. Contrary to previous results, Martin et al. (2009) did not find previous wildfire experience to influence risk perceptions or mitigation behaviors. The sample of findings noted here

highlight how the literature on risk perceptions and the decision to implement mitigation activities is inconclusive. Further work on this subject, coupled with assessing decision-making strategies, could shed light on exactly what factors influence risk perceptions and the decision to mitigation risk. It may also be fruitful to investigate the reciprocal relationship between risk perceptions and fire-management agencies' outreach efforts. Heightened risk awareness can lead individuals to seek out information from agency sources, and conversely, agency outreach can lead to increased risk awareness.

What Biophysical Aspects Of Prescribed Burning And Wildfire Have Been Less Focused On In Previous Research And Can They Be The Focus Of Future Research To Enhance Our Understanding Of Prescribed Burning And Wildfire As A Socio-ecological Phenomenon? (Biophysical Aspects of Fire)

Future work is needed on perceptions and behaviors as a function of forest ecosystem type

A number of studies (16%) included details about the specific forest ecosystem type in the study area in the introduction, methods, and results sections (Winter and Fried 2000; Gordon et al. 2010, 2010; Carroll et al. 2004). However, no previous research has analyzed the perceptions and behaviors of homeowners, residents, or fire professionals as a function of forest ecosystem type or its related fire regime. Similarly, no previous research has provided participants with forest ecosystem information as a frame of reference. A couple of studies provided parcel and tax lot information as a frame of reference (Fischer and Charnley 2012; Fischer 2011). However, it is interesting that most studies (86%) did not provide participants with information related to the forest ecosystem in question; there is no way to say that the results of these studies are products of perceptions, attitudes, etc. about the specific forest ecosystem the authors are addressing. Individuals typically use their surrounding area as a frame of reference, so it would be beneficial to provide participants information about the forest ecosystem and fire regime of the area in question. Fire regimes indicate spatial and temporal patterns and ecosystem impacts of fire on a given landscape, and change with vegetation type as well as weather and climate patterns. Information on specific forest ecosystem types and fire regimes should be identified and transparent to individuals when they are being solicited about their risk from prescribed burns and wildfire; this would provide an accurate frame of reference from which to answer risk perception, decision making, and other related questions. In studying the psychosocial aspects of wildfire, social scientists would

benefit from providing participants with information on the fire regime in the study area. This will enable individuals to be more informed about their actual level of fire risk and make more informed, context-specific, decisions.

Further, it has been shown that additional knowledge on fire generally increases fire tolerance (Cortner et al. 1984). Additional knowledge on fire coupled with information on specific ecosystem type and fire regime can provide a more accurate assessment of individuals' behaviors and behavioral intentions. Information on fire regimes can be integrated into fire managers and forestry professionals' outreach and education efforts targeted at homeowners and residents. With knowledge on how different stakeholder groups perceive information and risks, and make decisions on mitigation strategies, professionals can tailor information and outreach strategies specifically to meet the needs of different stakeholder groups in an area. Educational information should be geographically specific to help improve the likelihood fire-management decisions are accepted by locals (Cortner et al. 1984). In summary, to capture geographically specific information on perceptions and behaviors related to prescribed burning and wildfire, forest ecosystem and fire regime information should be provided to participants in future research.

Continued focus on the WUI can open up the possibilities for longitudinal analyses

Our review revealed that the WUI has been the focus of most research into perceptions and behaviors surrounding prescribed burning and wildfire. This is not surprising considering the WUI has increasing numbers of structures and area burned annually by wildfire, and protecting these structures is more challenging relative to other areas (Hammer et al. 2009). With the influx of new residents entering the WUI, there is a unique opportunity to assess decision-making strategies and mitigation behaviors within these areas before they expand outward and fire risk increases (Bihari and Ryan 2012). Since the majority of research has been done in the WUI, there is potential for longitudinal studies to show how attitudes, risk perceptions, decision-making strategies, and support for management has changed among homeowners/residents. Illustrating how these aspects have changed over time with exposure to, and education on, wildfire can provide critical information on how to begin addressing communities that have relatively less exposure, or a community that has only recently been established. Utilizing the information we have from previous work on developed WUI areas could provide insight to those previously rural or undeveloped areas that are urbanizing. Information on the 'lessons learned' from previous wildfire experiences in the WUI would be beneficial information for residents moving into the WUI where

wildfire risk is high. Since the WUI continues to expand over time, it will be beneficial to continue studying residents in the WUI to understand how their attitudes, planning efforts, and responses to, prescribed burning and wildfire change over time.

How Has Climate Change And Multiple Forest Disturbances/Hazards Been Included In Previous Work? (Fire Type and Management)

Climate change needs to be more thoroughly integrated into future work

Only two studies in this review specifically addressed homeowner perceptions of the influence of climate change and climate variability on wildfire risk or the need for prescribed burning (Ojerio et al. 2011; Schulte and Miller 2010). There is undoubtedly a need to include climate change as a more explicit factor influencing perceptions and behaviors surrounding prescribed burning and wildfire. Analyzing climate change knowledge related to prescribed burns and wildfire can illustrate how well individuals understand environmental processes at a larger scale. Individuals who understand climate change and believe it is happening, and have knowledge on the impacts to forests, are more likely to see the broader management goals that are associated with personal mitigation behaviors. For instance, a landowner or homeowner that understands the potential increase in fire risk associated with decreased annual precipitation and increased average temperatures can more readily conceptualize how those factors can increase the likelihood of a fire near their home. This understanding and thought process could push homeowners and residents to engage in mitigation behaviors that will protect themselves and their assets.

More work is needed on perceptions and behaviors related to multiple forest disturbances

Nearly all studies in this review (91%) have only assessed the psychosocial and biophysical aspects of fire, in comparison to fire and additional disturbances. Only five studies addressed fire and additional disturbances. An interesting result came from a recent study on wildfire and hurricanes (Newman et al. 2014). Individuals living near the ocean in the western part of Florida described hurricanes as being a greater risk relative to wildfire, even though fire is still a significant risk in that area. This is an example in how individuals order threats, based on what is visually apparent in their daily lives, and what seems to be a more catastrophic, unpredictable disturbance. Based on other gaps in the research, it would be interesting to analyze how residents/landowners order fire-specific threats relative to other

threats like drought and flooding events, and how knowledge on or belief in climate change influences how individuals order these threats.

Limitations

A limitation of our integrative review is that it does not capture the growing body of work describing community-level responses to prescribed burning and wildfire risks. Much of this work is theoretically focused and has not been grounded in empirical data. For example, Paveglio and his colleagues (2015), as well has Carroll and Paveglio (2016) have developed a conceptual approach to better understand adaptive capacity through 'community archetypes'. Paveglio and his colleagues (2016) have also described how different definitions of community can shape collective adaption. The conceptual and theoretical advances developed in this work certainly needs to be included in broader discussions focused on how to build more resilient and fire-adapted communities. Community-level research could provide a more comprehensive and realistic analysis of the dynamic nature of how diverse stakeholder groups interact and collectively prepare for and/or respond to, prescribed burning and wildfire. Recent research by some in the social science community acknowledge that inter-group relationships are critical to successfully preparing for and managing prescribed burning and wildfire (Nowell et al. 2017). The risks associated with prescribed and wildland fire are most effectively mitigated through the collective actions of a community. However, collective action is extremely difficult to measure (Meinzen-Dick et al. 2004; Poteete and Ostrom 2004). Conceptual and theoretical work can provide important insights into how different communities can mitigate the risks associated with prescribed and wildland fire; it can also provide insights into how those communities are likely to respond to uncontained prescribed burns and wildfire events.

Another limitation of this review is the focus on studies only in the United States. There have been a number of studies done in Australia (Anton and Lawrence 2016; McGee and Russell 2003) and Canada (Arvai et al. 2006; McGee et al. 2009) which have similar research objectives and methodological approaches. However, to avoid lengthy discussions of how international level geophysical, political, and social differences (e.g., differences in topography, climate, political structure, management, and land/homeowner programs) could influence the results of this study, international work has been excluded from this review. In the future, a global integrative review following the methodology we have utilized here would offer novel insights into the perceptions and behaviors of individuals dealing with prescribed and wildland fire.

Conclusion

In this review, we evaluated existing empirical research focused on individuals' perceptions and behaviors related to prescribed burning and wildfire in the United States. By organizing the review around four thematic categories, we have been able to systematically dissect and quantify how (theory and methods used) and what (psychosocial aspects of fire, biophysical aspects of fire, fire type, and management) research has been done. In this, we answered four general research questions which build on previous literature reviews: (1) What theories and methodologies have been used to understand individual perceptions and behaviors related to prescribed burning and wildfire?; (2) What groups of individuals have been studied in the past, and how can we include under-studied groups to improve our understanding of these groups' perceptions and behaviors related to prescribed burning and wildfire?; (3) What biophysical aspects of prescribed burning and wildfire have been less focused on in previous research and can they be the focus of future research to enhance our understanding of prescribed burning and wildfire as a socio-ecological phenomenon?; and (4) How has climate change and multiple forest disturbances/hazards been included in previous work? We have used our analysis to identify several areas across the thematic categories where future research is needed (summarized in Table 2). Our intent is to help social scientists focus their research on the areas where future work can make the greatest contribution to our collective understanding of perceptions and behaviors related to prescribed burning and wildfire.

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